# The Forest Health Video Series

## PRINT RESOURCE FOR DWARF MISTLETOE

Alberta
ENVIRONMENTAL PROTECTION

**The Forest Health Video Series** is designed for forest technicians, managers and those interested in educating themselves on the health of Alberta's forests.

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ENVIRONMENTAL PROTECTION

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# GENERAL INFORMATION

Forests are an important part of Alberta's heritage and foundation. They provide Albertans with a resource to achieve environmental, social, cultural, and economic goals. Moreover, forests play an important role in providing visual aesthetics and an ecological balance. As a result, over 8.8 million people visited Alberta's parks and recreational areas in 1996. Forests also provide fibre, contributing to the third largest industry in the province. In 1995, the forest industry provided employment for 40, 000 Albertans and brought revenues amounting to three billion dollars (Skory 1998). Thus sustaining healthy forests is important to Albertans.

Our ability to sustain healthy forests is severely limited by forest diseases. Between 1988 and 1992 insects and diseases accounted for 36% of the timber depleted in Alberta. (Figure 1; Brandt 1995). One such disease is lodgepole pine dwarf mistletoe (Arceuthobium americanum), commonly known as dwarf mistletoe. It is a small, vascular, flowering plant growing on the stems and branches of lodgepole pine (Pinus contorta var. latifolia) and jack pine (Pinus banksiana). Dwarf mistletoe inhibits growth, reduces fibre quality and seed production, and increases susceptibility to secondary pests, causes adverse environmental conditions and kills trees. Brandt (1995) found dwarf mistletoe was responsible for the annual volume loss of 780,000 m3 per year or around ten percent of the annual loss attributed to insects and diseases.

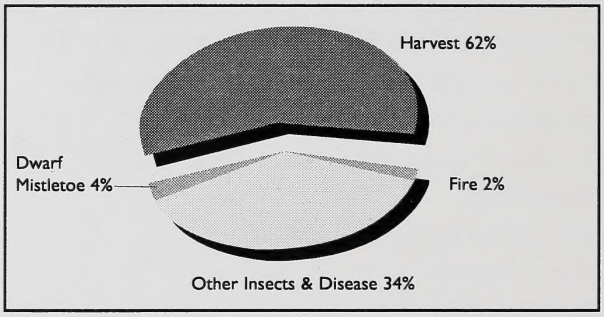


**Figure 1. Alberta's annual volume depletion** 1988-1992 (Brandt 1995)

# PRINT RESOURCE INTRODUCTION

This print resource by Alberta Environmental Protection, Land and Forest Service, focuses on lodgepole pine dwarf mistletoe (Arceuthobium americanum). It contains information on dwarf mistletoe biology, assessment, prevention, and management practices. Forest resource managers are strongly encouraged to use this manual, along with the **Forest Health Video Series: Dwarf Mistletoe**, as a reference and teaching guide to understand the biology, spread and management of lodgepole pine dwarf mistletoe in Alberta.

**This fact sheet has three objectives:**

1. To assist in dwarf mistletoe recognition and identification.
2. To provide tools to accurately assess and measure dwarf mistletoe infection.
3. To provide guidelines and management options for effective dwarf mistletoe management.

## TOPICS ADDRESSED IN THE FOREST HEALTH VIDEO SERIES: DWARF MISTLETOE

The following is a general outline of key points addressed in the **Forest Health Video Series: Dwarf Mistletoe.**

### Topics:

### General introduction:
**00:00-03:20**
1. Forest management objectives.
2. Silviculture definition.
3. Dwarf mistletoe introduction.

### Identification:
**03:20-05:41**
1. Witches' brooms.
2. Localized swelling on branches.
3. Thinning tree crowns.
4. Distorted tree growth.
5. Green or yellow aerial shoots.
6. Basal cups.

### Life cycle:
**05:42-06:56**
1. Seed germination and interception.
2. Swelling of the infected area.
3. Shoot and seed production.

### Seed dispersal characteristics:
**06:57-08:20**
1. Incidence and rate of seed infection.
2. Even-story stands.
3. Multi-story stands.

### Factors determining control options:
**08:21-08:33**
1. Overall stand health.
2. Economics.
3. Public Safety.
4. Biological concerns.
5. Aesthetics.

### Factors determining treatment options:
**08:34-09:22**
1. Growth loss.
2. Incidence of detection.
3. Mortality rate.

### Management practices:
**09:22-11:59**
1. Clear cutting.
2. Buffers.
3. Overstory removal.
4. Commercial thinning.
5. Use of resistant species.

### Practices promoting spread:
**12:00-15:35**
1. Selective logging.
2. High grading.
3. Diameter limit harvesting.

### Hawksworth's five points:
**15:36-18:00**
1. Plant parasite.
2. Host specific.
3. Slow growth.
4. Slow rate of spread.
5. Easy to detect.

# LIFE CYCLE

The life cycle of lodgepole pine dwarf mistletoe takes approximately five to six years to complete (Baranyay and Smith 1972).

## First year

At maturity, from mid August until September, the fruit ejects a seed at speeds of up to 97 km/hr (Hinds et al 1963). On average, seeds travel 3 m but have been known to travel distances of up to 15 m (Baranyay and Smith 1972). Only a few seeds stick to the needles of the host. After the first rainfall, gravity pulls the seed to the base of the branch where the seed will penetrate the host and establish a foundation. Shortly after, the endophytic system begins to develop.

## Second to sixth year

In the second year, the endophytic system continues to develop and the branch begins to swell around the point of infection. Shoot production begins and the aerial shoots will be visible between the third and fourth year (Baranyay and Smith 1972). In the fourth year, shoot production is followed by flower development. Pollination and fertilization occur in the fifth year, and the fruit matures by May of the following year. Shortly afterwards, the life cycle repeats.

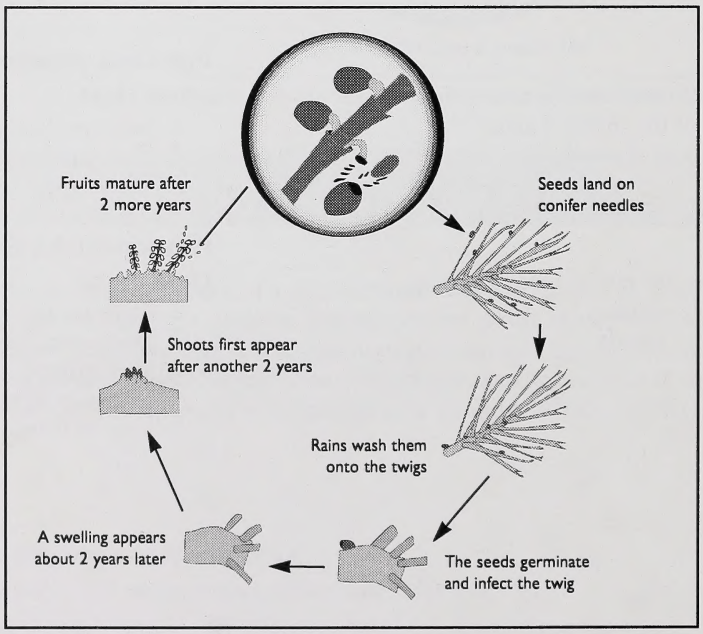


**Figure 2. Life cycle of Dwarf Mistletoe**

# IDENTIFICATION

The following visual characteristics are associated with dwarf mistletoe infection:

- The presence of localized swelling on branches. (Figure 3A.)
- Distorted tree growth. (Figure 3B)
- Thinning of tree crowns. (Figure 3C)
- Appearance of small yellow or green dwarf mistletoe shoots. (Figure 3D.)
- Witches' broom (abnormal growth of branches clumped together). (Figure 3E.)

## Morphological characteristics

Accurate and quick identification is essential for effective silvicultural controlling of dwarf mistletoe. The following is a summary of the major identifiable morphological characteristics of dwarf mistletoe (Hawksworth and Wiens 1996)

## Shoots

Shoots are squaemate (scale-like) and are green or yellow in colour. They are 1-5 cm long, 1-3 mm wide and grow on the branches or stems of infected lodgepole or jack pine. Shoots should be visible by the fourth year after the initial infection.

## Flower

All dwarf mistletoes are dioecious (male and female flowers are produced on different plants). The female flower is 1.5 mm long and 1.9 mm wide. The flowers are attached directly to the stem at the node without a supporting stalk. The male flower is simple and has one whorl (ring-like arrangement) consisting of three similar parts. It is usually the same colour as the shoots. Each anther within the stamen is bright yellow. The flowers appear during April and May in the fourth year of its life cycle.

## Fruits

Fruits (berries) develop from the female flowers. They are 3-5 mm long and 1-2 mm wide. A mature fruit is covered with a whitish or bluish wax coating. The upper one-third is yellow and the lower two-thirds is green. The fruits appear in the spring of the fifth year and take one year to mature. Seed dispersal begins in mid-August and lasts until mid-September of the sixth year.

**Questions:**

1. What are three identifiable characteristics of lodgepole pine dwarf mistletoe?
2. Define the term "dioecious."
3. What point in the life cycle of dwarf mistletoe is of greatest concern for forest managers?
4. What is the average dwarf mistletoe life-span

# ENDOPHYTIC SYSTEM

The endophytic system is comprised of three major components: the radicle, the cortical strands, and the sinkers (Hawksworth and Wiens 1996). Its function is to establish a foundation and provide a mechanism to absorb and transport water and nutrients from the host to the parasite.

The radicle is the initial component produced by the germinating seed. It forms a penetration wedge that uses mechanical forces to penetrate and bond to the protective layers of the stem.

The cortical strands develop out from and perpendicular to the penetration wedge. They grow around the inner circumference of the stem or branch causing swelling at the point of infection.

Sinkers grow vertically downward from the cortical strands just past the cambium into the xylem. Both the cortical strands and the sinkers extract water and nutrients from the tree.

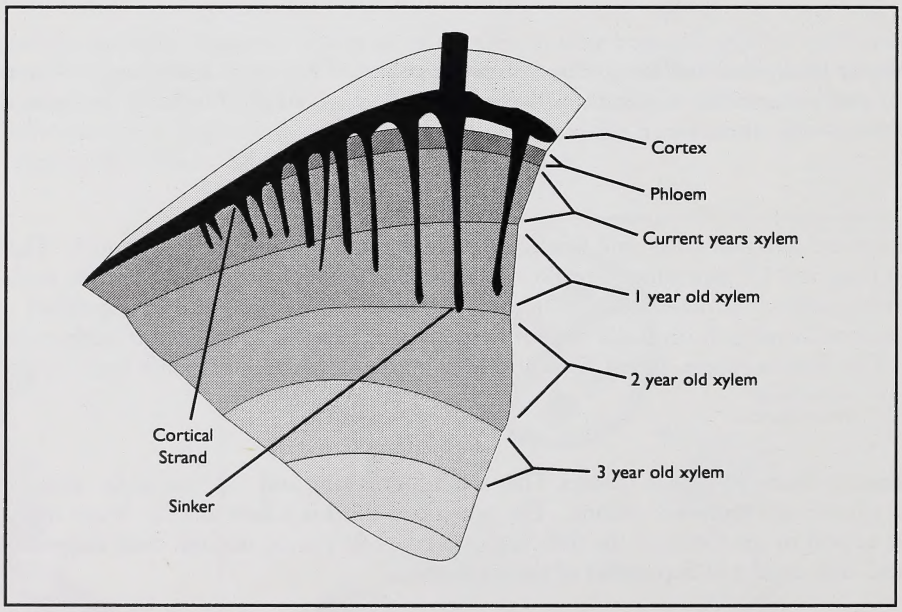


**Figure 4. Illustration of the endophytitic system of Dwarf Mistletoe**

# SEED DISPERSAL AND STAND CHARACTERISTICS

The rate of seed dispersal is affected by stand characteristics. Multi-age stands have a faster seed dispersal rate than even-age stands. The seed dispersal rate in a multi-story stand is 9 -15 m/year and the seed dispersal rate in an even-story stand is 0.3 - 0.6 m/year (Baranyay and Smith 1972). The rate of seed dispersal in multi-story stands is faster because the surface area available to intercept the seeds is greater in multi-story stands than in even-age stands. (Figure 5 & 6.)

The age of the stand is a factor in determining the likelihood of dwarf mistletoe infection. Stands up to seven years of age are least likely to be infected because of the small surface area available for seed interception (Muir 1972). Hawksworth and Hinds (1963) found that 30 year old lodgepole pine, initially free from dwarf mistletoe, were infected by residual trees within nine metres.

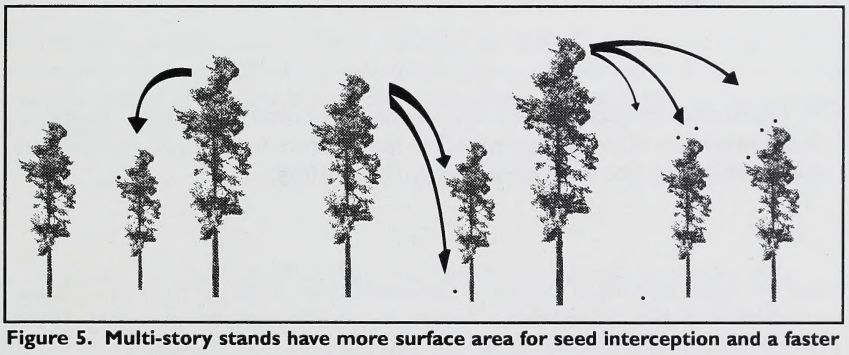

**Figure 5. Multi-story stands have more surface area for seed interception and a faster seed dispersal rate (9-15 m/year).**

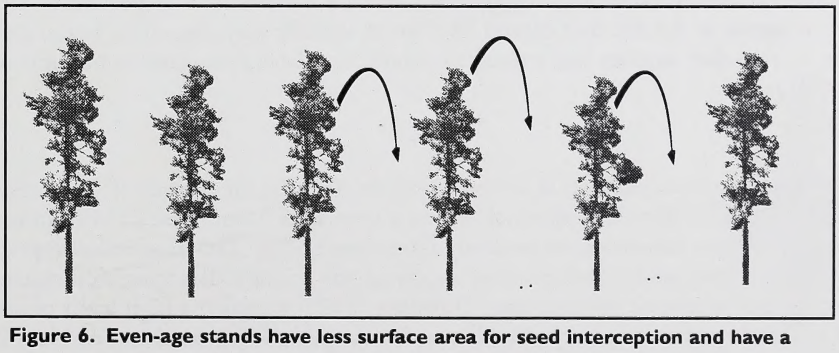

**Figure 6. Even-age stands have less surface area for seed interception and have a slower seed dispersal rate (0.3-0.6 m/year).**

**Questions:**

1. What stand composition is associated with a slower rate of dwarf mistletoe infection?
2. How does the available surface area affect the probability of infection?

# FACTORS AFFECTING DISTRIBUTION AND GROWTH

Climate, wildfire, topography, soil, and forest management practices are factors that affect the growth and distribution of dwarf mistletoe.

## Climate

Smith and Wass (1979) found that temperature is a limiting factor of dwarf mistletoe. Temperatures lower than –39°C can kill dwarf mistletoe. Optimal germination temperature is 16°C. At temperatures below 12°C the success of seed germination decreases significantly (Muir 1968).

## Wild Fire

Fire has historically been the most important factor in the distribution of dwarf mistletoe. It has been found to reduce the occurrence of the disease but, in some cases, cause increased infection. If a fire that goes through an area is hot enough and destroys all of the infected trees then the stand will be sanitized and new growth will not be affected by residual dwarf mistletoe infection. If the fire burns less intensely or leaves infected trees then the spread of the disease may actually be greater in newly formed stands than if the area was clearcut and no infected advanced regeneration was left behind. It is important to monitor burnt areas for dwarf mistletoe as the fire that caused fibre losses initially may also affect future yields and wood quality. This is an area that requires more research, which may have management implications in terms of prescribed burning.

## Topography

It is uncertain whether topographical position is another variable affecting the growth of dwarf mistletoe. In Alberta, the highest and lowest elevations at which infected trees were found were 2134 m in southern Alberta and 213 m north of Lake Athabasca, respectively (Baranyay 1970). This may reflect topography but may also be the effect of temperature and growing season on the parasite. Topographical variance has also shown an effect on dwarf mistletoe populations. Dowding (1929) recorded a high levels of lodgepole pine dwarf mistletoe infected trees on ridge tops in Alberta, intermediate levels on slopes and low levels of the parasite at the base in valleys.

## Site Quality

Although there is little information on abundance of dwarf mistletoe in relation to site quality there is a relationship between site quality and the host tree mortality (Hawkesworth and Johnson 1989a, van der Camp 1987). It has been proposed that poor site quality (too wet or too dry, nutrient poor soil, etc...) may cause an increase in infected tree mortality but may limit the spread rates of the disease. Further research in this area is needed to determine the effect site quality has on pine mortality and rates of dispersion of the parasite.

## Forest management practices

Forest management practices are yet another factor affecting the growth and spread of dwarf mistletoe. Management practices, such as a prescribed burn or clear cutting, are one of the most influential factors affecting the growth and spread of lodgepole pine dwarf mistletoe. We will discuss this in more detail in the section Managing Dwarf Mistletoe.

#### Questions

1. List one positive and one negative effect that dwarf mistletoe has on the environment.
2. List and describe other affected variables that should be considered when managing dwarf mistletoe.

# HAWKSWORTH 6-CLASS RATING SYSTEM

The most common system used in North America to describe the severity of dwarf mistletoe infection is the Hawksworth 6-class rating system. Frank G. Hawksworth developed this rating system to assess and measure dwarf mistletoe infection. Refer to Figure 8 for an example and instructions on Hawksworth 6-class rating system.

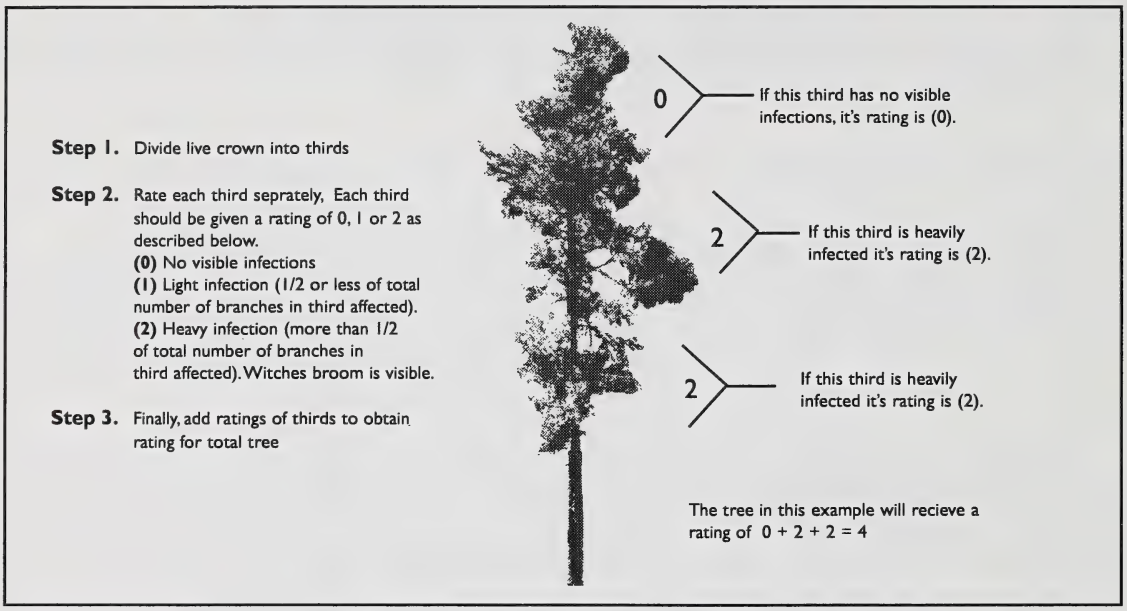


**Figure 7. Annotated illustration of Hawkesworth's 6-class rating system**

# ASSESSMENT

The impact of dwarf mistletoe on humans depends on land use objectives, which include fibre production, recreation, conservation, and wildlife. Five variables to consider when assessing trees or stands infected by dwarf mistletoe are overall stand health, economics, severity of infection, wildlife, and public safety. The consideration of these variables helps to make an objective assessment.

## Overall stand health

A healthy tree may be able to outgrow infection of dwarf mistletoe in the lower crown. If the infection is light to moderate, then a vigorous stand may still be able to produce an adequate volume of marketable timber. In this case, it would be wise to leave the stand alone. (Figure 8.) However, if a weak stand were infected, whether it is in the top or bottom tree crown, then it would be beneficial to clear and regenerate the stand. Make sure that no infected trees are left standing when the infected stand is cleared.

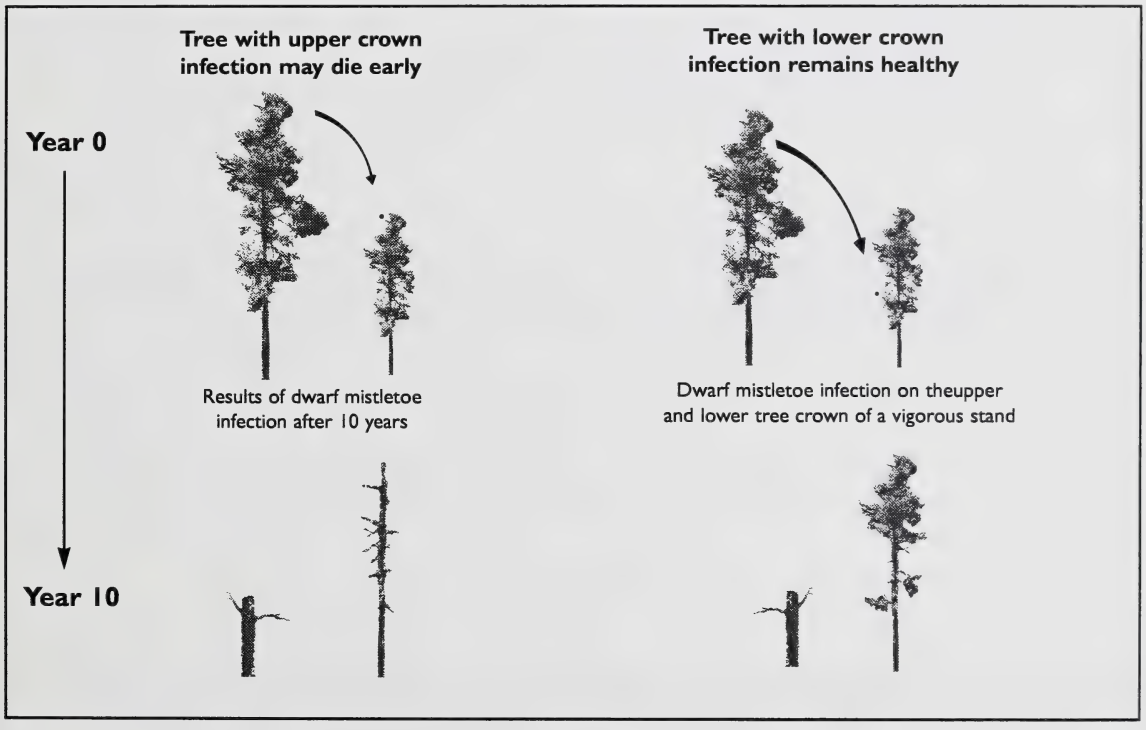


**Figure 8. Results of Dwarf Mistletoe infection after 10 years on upper and lower crown.**

## Economics

Cost benefit analysis (CBA) is one useful tool in the decision-making process. It compares costs and benefits associated with an action over time. The results of the analysis will favour the action with the greatest net benefit. However, non-market values (i.e. aesthetics, existence value, biodiversity) are often difficult to measure, preventing an accurate cost benefit analysis.

## Severity of infection

A healthy tree (dwarf mistletoe rating of 0) will have a greater percentage of timber remaining than a heavily infected tree (dwarf mistletoe rating of 6). Therefore, when the main land use objective is fibre production, the most severely infected stands should be harvested first.

## Public safety

In parks and recreational areas, branches with witches' brooms often break easily under strong winds or heavy snowfall. This has caused personal injury and property damage. Therefore, clearing infected stands or pruning witches' brooms in heavy use areas may help improve public safety.

**Questions:**

1. List and describe other variables to consider when assessing an infected area.
2. Can information about seed dispersal be helpful in the dwarf mistletoe assessment process, and, if so, how?
3. What are three ways to determine the overall health of a stand and the degree of dwarf mistletoe infection?

# MANAGEMENT OF DWARF MISTLETOE

The management of lodgepole pine dwarf mistletoe is feasible because of its distinct appearance, long reproductive life cycle, species-specific host, and predictable seed dispersal characteristics. These variables allow for proficient control over dwarf mistletoe disease when effective management strategies are implemented. Dwarf mistletoe management strategies include not only active management of existing infected stands but also involve careful planning in preventing further infection.

Identifying, reporting, and mapping infected areas are three initial steps to improve dwarf mistletoe management. The three key identifiable characteristics of lodgepole pine dwarf mistletoe are the presence of witches' brooms, distorted growth of branches, and a thinning tree crown present on lodgepole or jack pine. Infected areas should be reported quickly so that a plan of action can be designed, assessed, and implemented. This plan of action should define land use objectives and the dwarf mistletoe's role within the environment, coinciding with the Alberta's Timber Harvest Planning and Operating Ground Rules.

Each forest stand has its own site-specific characteristics making the stand unique. Therefore, forest managers must use their practical experience, sound judgement, and knowledge of lodgepole pine dwarf mistletoe to determine and implement the best course of action to better manage this plant. Ideally, forest managers will be able to use this fact sheet by applying it to the diverse situations they face.

## Management options

The following options can be used alone or in combination with other options to manage dwarf mistletoe.

1. Harvesting and regenerating stand
2. Prescribed burn and regenerating stand
3. Over-story removal
4. Commercial thinning
5. Pruning
6. Doing nothing
7. Creating buffers
8. Using resistant species
9. Residual removal

(Currently there are no chemical, biological, or genetic options for managing dwarf mistletoe)

### 1. Harvesting and regenerating

If a stand is infected and is still marketable, it can be harvested and regenerated. This is the most effective way to eradicate dwarf mistletoe. All infected trees should be felled after a harvest to prevent infection in a regenerating or nearby stand.

**Seven criteria to consider when harvesting:**

1. Clearcuts should be larger than 8 hectares.
2. Clearcuts should have a low perimeter to area ratio. (Figure 10.)
3. Clearcuts should have a regular shape, i.e., block.
4. Trees within 30 m of the infected area should be removed.
5. Avoid clearing narrow strips of infected stands. This strip pattern leads to an increased probability of infestation of regeneration.
6. All infected trees in a clear-cut should be felled.
7. The buffers and trees for wildlife should be selected from uninfected pine or non-pine species

**Use low perimeter to area ratio** **Avoid high perimeter to area ratio**

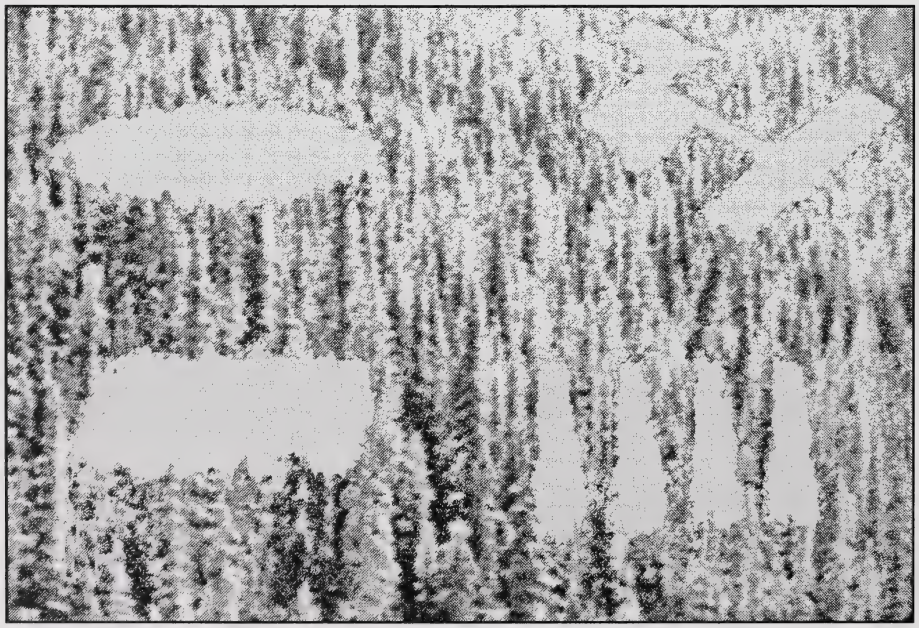

**Figure 9. Illustration of desirable versus undesirable cutting practices when managing for dwarf mistletoe.**

**2. Prescribed burn and regenerating**

If a stand is infected and not merchantable, it can be cleared by a prescribed burn and then regenerated. In a cleared stand, all infected trees should be felled to prevent infection in a regenerating or nearby stand.

**3. Over-story removal**

Transmission of dwarf mistletoe is faster in a multi-story stand than in an even-age stand. Therefore, infected over-story trees in a multi-story stand should be removed to create a more even-age stand. If infected trees remain in sight then they should be cleared before regenerating the stand.

**4. Commercial thinning**

Commercial thinning to remove severely infected trees may be a viable option. Thinning should be done in stands where the dwarf mistletoe rating is 2 or less. In lightly infected stands, thinning will show significant increases in timber yield. Commercial thinning is not recommended for stands with a dwarf mistletoe rating 3 or higher.

**5. Pruning**

In campgrounds and recreation sites where public safety and aesthetics are important, pruning may be a course of action in controlling dwarf mistletoe. Although pruning does not eradicate the disease within the host, it will prolong the life of the tree. Pruned trees should be rechecked 5 to 7 years after treatment for any additional infection. Pruning can also be considered in commercial stands with the lower tree crown infected, thus promoting further tree growth.

**Five criteria to consider when pruning:**

1. Lightly infected stands (up to 15 years of age) may be pruned.
2. Do not prune a tree when half the crown is infected.
3. If the infection is within 10 cm from the tree trunk, the entire tree should be removed.
4. Heavily infected trees should be removed before lightly infected trees are pruned.
5. Remove two or more branches around and above the highest visible infection.

**6. Creation of dwarf mistletoe buffers**

Creating buffers (i.e., natural or man made clearings, open areas, planting resistant tree species) can reduce the spread of dwarf mistletoe from infected stands to the surrounding ones. Buffers should be a minimum of 30 meters in width. Some examples of buffers are open spaces, roads, lakes, rivers, or trees resistant to dwarf mistletoe (i.e. non-pine tree species).

**7. Doing nothing**

This process may be considered if other options are not viable to the site-specific conditions.

**8. Using resistant species**

Resistant species that can be used are non-pine species. E.g. spruce, balsam fir, and aspen.

**9. Residual removal**

All infected trees in a clear-cut should be felled but they can remain on the ground.

## Management options for lodgepole pine dwarf mistletoe

| **Primary objective** | Recreation / Residential | Fibre production for trees < 30 years | Fibre production for trees > 30 years | Wildlife |
|---|---|---|---|---|
| **Lightly infected stand** | 5, 6, 7 | 3, 4, 5, 6, 7 | 4, 5, 6, 7 | 3, 5, 6, 7 |
| **Severely infected stand** | 1,2, 3, 5 | 1,2, 3, 6, 7 | 1, 2, 7 | 6, 7 |

# RESEARCH

In the United States, research is being conducted in the areas of chemistry, biology, and genetics for managing dwarf mistletoe.

Ethephon (Florel), which inhibits the growth of dwarf mistletoe shoots, is used in some areas to manage dwarf mistletoe. This chemical is not only very expensive to use but repeated treatments are required. Research to find a chemical that is cheaper and more effective is underway to provide another option for managing dwarf mistletoe.

Three common parasitic insects known to inhibit growth and transmission of dwarf mistletoe are *Wallrothiella arceuthobii*, *Septogloeum gillii*, and *Colletotrichum gloeosporioides*. These parasites destroy only the shoots and leave the endophytic system in place, which continues to re-sprout. Research is being conducted to find organisms that are easily distributed and effective in inhibiting the growth of dwarf mistletoe.

## Computer assessment model

Edminster (1978) has developed a dwarf mistletoe simulations program for the Central Rocky Mountains. It predicts the yield of lodgepole pine dwarf mistletoe stands and offers management options with regards to site-specific conditions. Moreover, predicted yields of a given stand from two different treatments can be compared. This may be adopted in the assessment and management of lodgepole pine in Alberta.

# AN ALBERTA EXAMPLE

In Alberta, Sunpine Forest Products is managing for dwarf mistletoe in a number of ways. Initially, they have done pre-identification and severity ratings during the cruising and preharvest silviculture assessment processes. Once dwarf mistletoe is detected their harvest design places infected stands as a priority. The harvest is designed for a low perimeter to area ratio to ensure the least amount of impact from infected residuals. They also use existing clearings, both man made and natural, as cutblock boundaries to provide protection of residual stands. Cleaning up infected residuals after harvest is another policy they use to prevent spread to regenerating stands. Finally the company also plants 30 m white spruce buffers adjacent to infected residual stands. These dwarf mistletoe management strategies recognize the negative impacts of spread into regenerating blocks.

This disease management program involves many people. Contractors, planners and operations staff are all familiar with disease identification. The objectives of the management program are also familiar to staff at all levels. Involving staff and providing them with a rationale for the program ensures that the objectives are met.

# CONCLUSION

Infections of dwarf mistletoe can be effectively managed by common silvicultural practices. There has been a large amount of research on dwarf mistletoe. This research has been applied to the broad range of values and uses the forest offers us. Many of the management prescriptions are based on applying this information in a timely fashion. However, it is imperative that those on the front line provide forest managers with accurate information. Without this, any prescription has the potential, not only to fail, but possibly to make worse the problem trying to be fixed. Proper identification and accurate mapping of infected stands is extremely important.

# REFERENCES


Baranyay, J.A., R.B. Smith. 1973. Dwarf mistletoes in British Columbia and recommendations for their control. Department of Fisheries and Forestry. Canadian Forestry Service. BC-X-72.

Baranyay, J.A. 1970. Lodgepole pine dwarf mistletoe in Alberta. Department of Fisheries and Forestry. Canadian Forestry Service. Publication No. 1286.

Bennetts, R.E., G.C. White, F.G. Hawksworth, S.E. Severs. 1996. The influence of dwarf mistletoe on bird communities in colorado ponderosa pine forest. Ecological Applications, 6(3). pp. 899-909.

Borland, J. 1997. Dwarf mistletoe revisited. Genescene. Colorado.
http:www.rmi.net/genesee/html/dwarf_mistletoe.html.

Dowding, E.S. 1929. The vegetation of Alberta. The sand hill areas of central Alberta with particular reference to the ecology of }{\i Arceuthobium americanum}{ Nutt. Journal of Ecology. 17(1). pp. 82-105.

Douglas, D. 1914. Journal kept by David Douglas during his travels in North America. New York: Antiquarian Press, Ltd. pp. 364.

Muir, J.A. 1972. Increase of dwarf mistletoe infection on young lodgepole pine. Canadian Journal of Forest Research. 2}{\lang1024 (4). pp. 413-416.}{

Muir, J.A. 1968. Biology of dwarf mistletoe (}{\i Arceuthobium americanum}{) in Alberta. Forest Research Laboratory. Calgary, Alberta. Internal Report. A-15.

Hawksworth, F.G., O.J. Dooling. 1984. Forest insects and disease leaflet 18:lodgepole pine dwarf mistletoe. U.S. Department of Agriculture, Forest Service. Pacific Northwest Region. R6 Forest Insects and Diseases.

Hawksworth, F.G., D.W. Johnson. 1989
. Biology and management of dwarf mistletoe in lodgepole pine in the rock mountains. Gen. Tech. Rep. RM-36. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. Rocky Mountain Forest and Range Experiment Station. pp. 4-27.

Hawksworth, F.G., D.W. Johnson.1993. You can save your trees from dwarf mistletoe. Gen. Tech. Rep. RM-225. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. Rocky Mountain Forest and Range Experiment Station. pp. 1-9.

Hawksworth, F. G., R.F. Scharpf. 1984. Biology of dwarf mistletoe: proceedings of the symposium. Gen. Tech. Rep. RM-111. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. Rocky Mountain Forest and Range Experiment Station.

Hawksworth, F.G.,D. Wiens. 1996. Dwarf mistletoes: biology, pathology, and systematics. U.S. Department of Agriculture, Forest Service. Washington DC. pp. 7-139.

Scharpf, R.F., J.R. Parmeter Jr. 1978. Proceedings of the symposium on dwarf mistletoe control through forest management. Gen. Tech. Rep. PSW-31. Berkeley, California: U.S. Department of Agriculture, Forest Service. Pacific Southwest Forest and Range Experiment Station. pp. 5-30.

Smith, R.B., E.F.Wass. 1979. Infection trials with three dwarf mistletoe species within and beyond their known ranges in British Columbia. Canadian Journal of Plant Pathology. 1. pp.47-57.

# NOTES